Overview of Army Robotic Convoy Technology Programs

Robobusiness 2007

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **15 MAY 2007**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Overview of Army Robotic Convey Technology Programs - Robobusiness 2007**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Teems, Justin**	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **REDCOM TARDEC 6501 E 11 Mile Road Warren, MI 48397-5000**	8. PERFORMING ORGANIZATION REPORT NUMBER **17098**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) **TARDEC** 11. SPONSOR/MONITOR'S REPORT NUMBER(S) **17098**

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**19**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DoD Logistics and Convoy Challenges

DoD logistics personnel face inherent challenges daily

- IEDs and other low tech attacks
- Threat level places additional personnel in harm's way for convoy defense
- Truck operators vulnerable to enemy ambush (lack of up-to-date situational awareness)
- Long 18 hour days take a toll on truck operators

The Challenge:

Effectively utilize existing automation technology to enhance soldier performance/reduce threat exposure, increase OPTEMPO while conducting the 3 Ds:

Dull, Dirty, or Dangerous

Benefits of Robotic Convoy

Offers tactical flexibility to convoy commanders.

Enables the convoy to move at precise speeds and spacing creating a more efficient convoy and reducing the risk of accidents.

Since the soldiers do not have to drive they can concentrate on communicating, planning and identifying enemies.

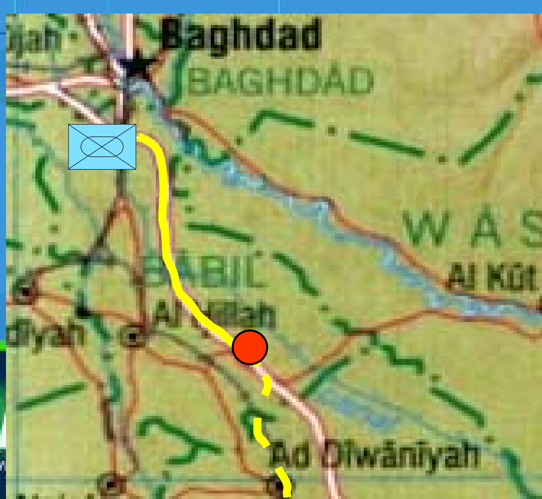
Driving workload of soldiers is reduced, allowing for increased force protection and situational awareness

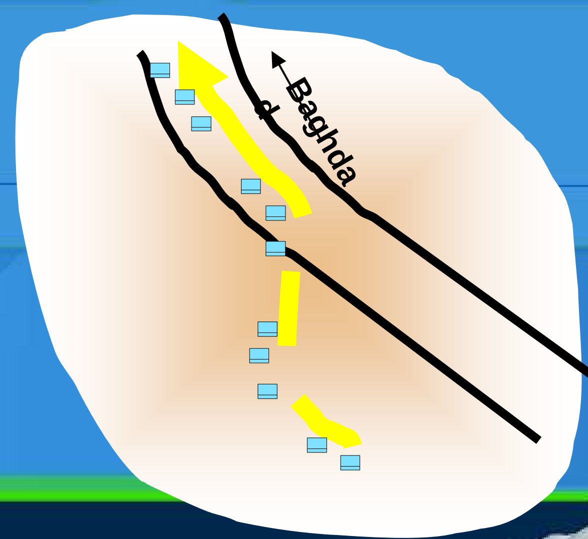
Mission planning is automated .

Robotic perception identifies and avoids obstacles without soldier intervention.

Robotic vehicles automatically adjust spacing .

The vehicles automatically avoid both positive & negative obstacles while picking the most efficient path.





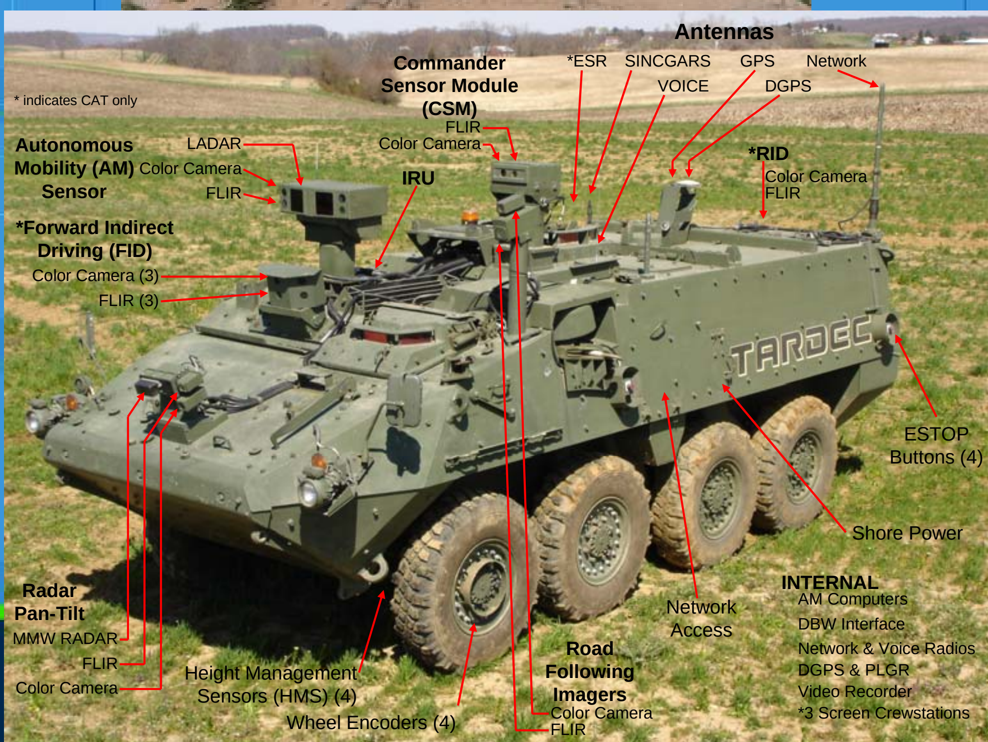
Marching Orders from the MILDEP

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

Devise a focused effort to demonstrate convincing evidence of the viability of unmanned tactical wheeled vehicles performing convoy driving/maneuver functions in military relevant environment(s) using available/affordable robotic follower technologies within 1 year.

Conduct engineering and User evaluations necessary to determine whether there is basis for accelerating the insertion of robotic convoy capability into the Current Force tactical wheeled vehicle fleet.

Robotic Follower Challenge



Problem:

Current robotics technologies lack battlefield mobility, speed and robustness for Future Force applications.

Challenges:

Autonomous technology capability projections don't meet FCS requirements.

Unmanned systems following manned vehicles with significant physical or temporal separation.

Detecting/avoiding new obstacles in the follower's path.

Operation in live traffic.

What are the technical barriers to this problem?

Current sensor ranges and resolutions limit effective following speeds.

GPS availability and quality doesn't support follower accuracies.

How will you overcome those technical barriers?

Rely upon a manned lead vehicle to "proof" terrain for following unmanned systems, taking advantage of human sensing and reasoning to reduce the burden on the unmanned systems.

Pass lead path to follower vehicles using "electronic breadcrumbs".

Employ a combination of sensors to look for obstacles, providing the best sensor for multiple conditions (day, night, vegetation).

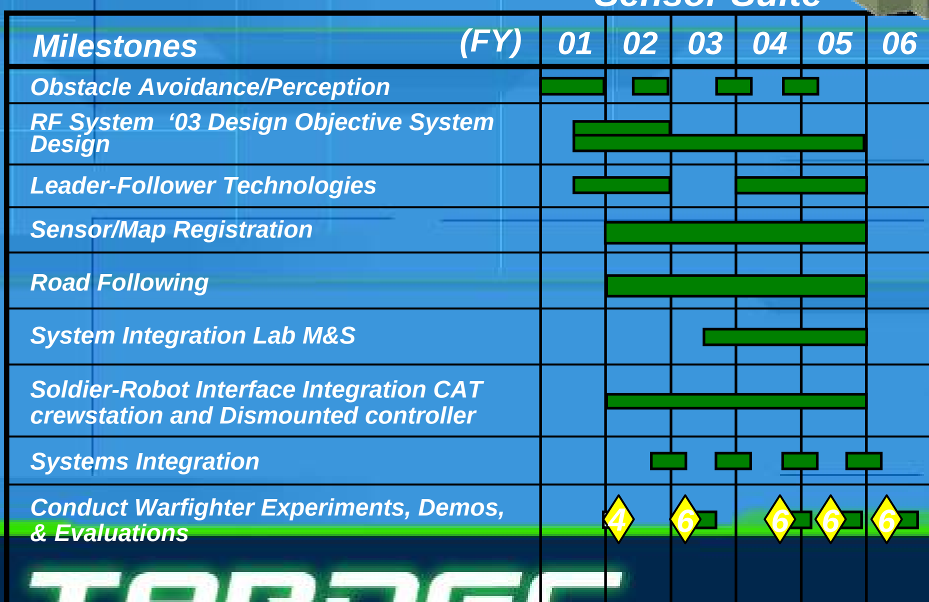
Use feature data from lead vehicle's perception system and register that with the follower's perception system for improved accuracies

Robotic Follower
Advanced Technology Demonstration

Mature & Demonstrate Robotics Technology Required for Early Insertion into FCS

FOR A SUPERIOR ARMY

Autonomous Mobility Sensor Suite



Purpose:

- Provide mounted leader-follower capability to PM, FCS (BCT) for ANS and integration into ARV, MULE and MGV's for resupply, rear security and NLOS/BLOS Fire mission
- Provide dismounted leader-follower capability to PM, Soldier Warrior for integration into Land Warrior Advanced Capability for MULE application

Product:

- Ruck truck resupply & mule capability
- Follower algorithms, engineering test data, and tactical knowledge transfer to PM, FCS (BCT) and FCS LSI in FY03- FY06
    - FCS UGV Risk Mgt Plan (CT 18)
- H/W, S/W improvements and M&S results to FCS LSI through FY06

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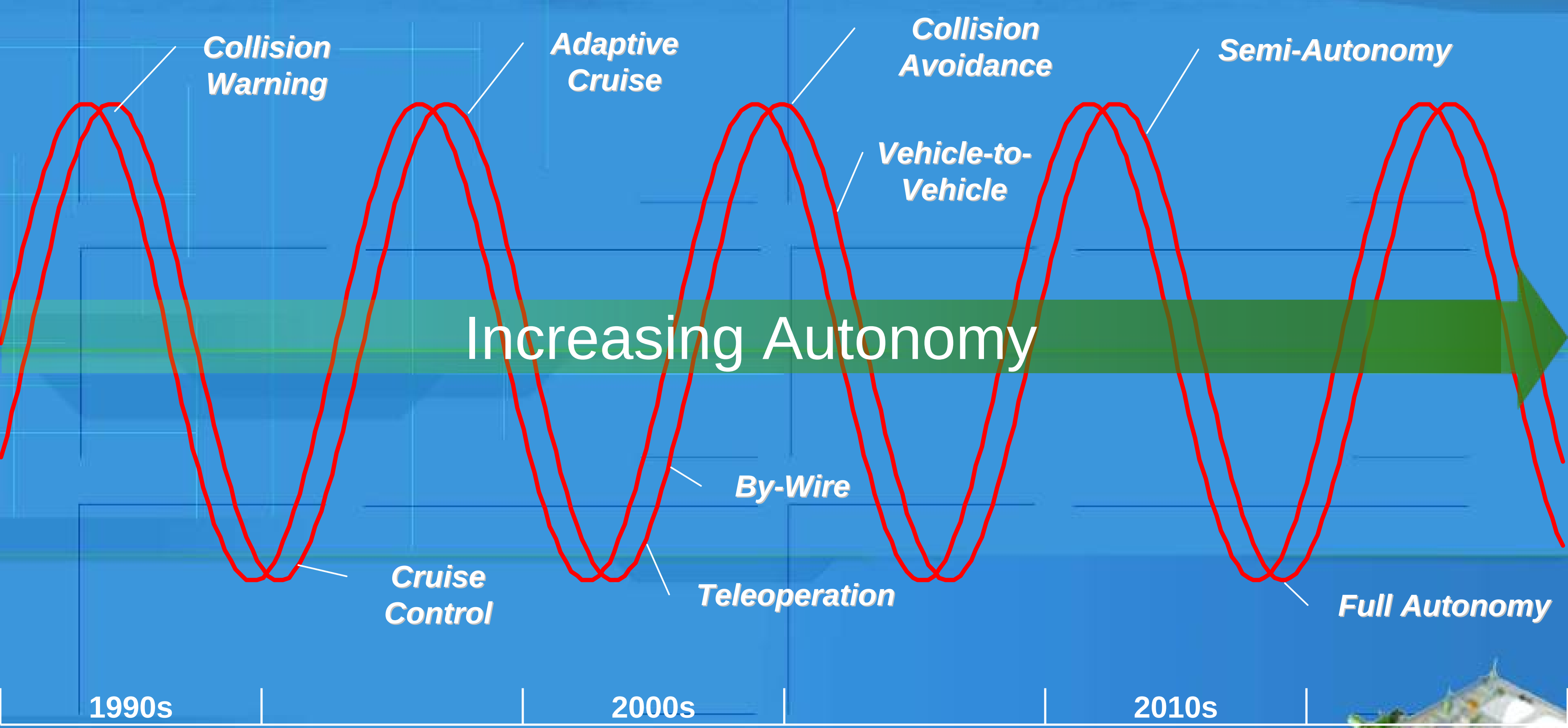
Robotic Follower Integration for FCS Autonomous Navigation System

ANS is the heart of the robotic vehicle. ANS robustness bounds the mission capability of the FCS vehicles (ARV, MULE & MGVs)

- Robotic Follower operational procedures and Unit of Action TTP development and refinement
- High speed autonomous convoy on narrow roads
- Feature based registration for Leader-Follower (non-GPS)
- Human odometry/dismounted follower
- Baseline convoy with live traffic
- Vehicle following behavior
- Baseline safety operational procedures
- Road/trail following
- Systems integration, testing and soldier evaluation
- Radar integration for vehicle tracking and collision avoidance

Progression of Autonomy



Convoy Active Safety Technologies (CAST) Origins and Impacts

S&T Reqs

Robotic Follower ATD
- Transitions to FCS ANS
- Completed in 2006

Technology Transfer

FCS Autonomous Navigation System
- ANS provides leader follower for ARVs, MULEs and MGVs
- Fielded to FCS Experimental Element in 2012

S&T Reqs

CAST
- Develop a cost-effective solution for Current Force trucks
- Leverage S&T and commercial technologies
- Support FMTV system Development
- Lay groundwork for robotics in outyears (08-13 Truck Buys)

Transition Technologies and Lessons Learned to FCS

Generate support from PEO and meet needs of the soldier

Stimulate formal Requirements Generation

PEO CS/CSS
- FMTV-A1R, A2
- Outyear Funding (POM)

Feed Requirements back into program to meet warfighter need

CASCOM/TRADOC
- Demonstrate Capability, which may lead to a requirement for Robotics with the Current Force

Requirements enable POM Cycle

Vehicle Overview

Video

Assumptions and Challenges

Assumptions

WAAS GPS is reliable (7-10 m) and available

Navigation alone will be sufficient to get through large turns

Perception supplements navigation inaccuracies to decrease lateral offset

Challenges found during EETs

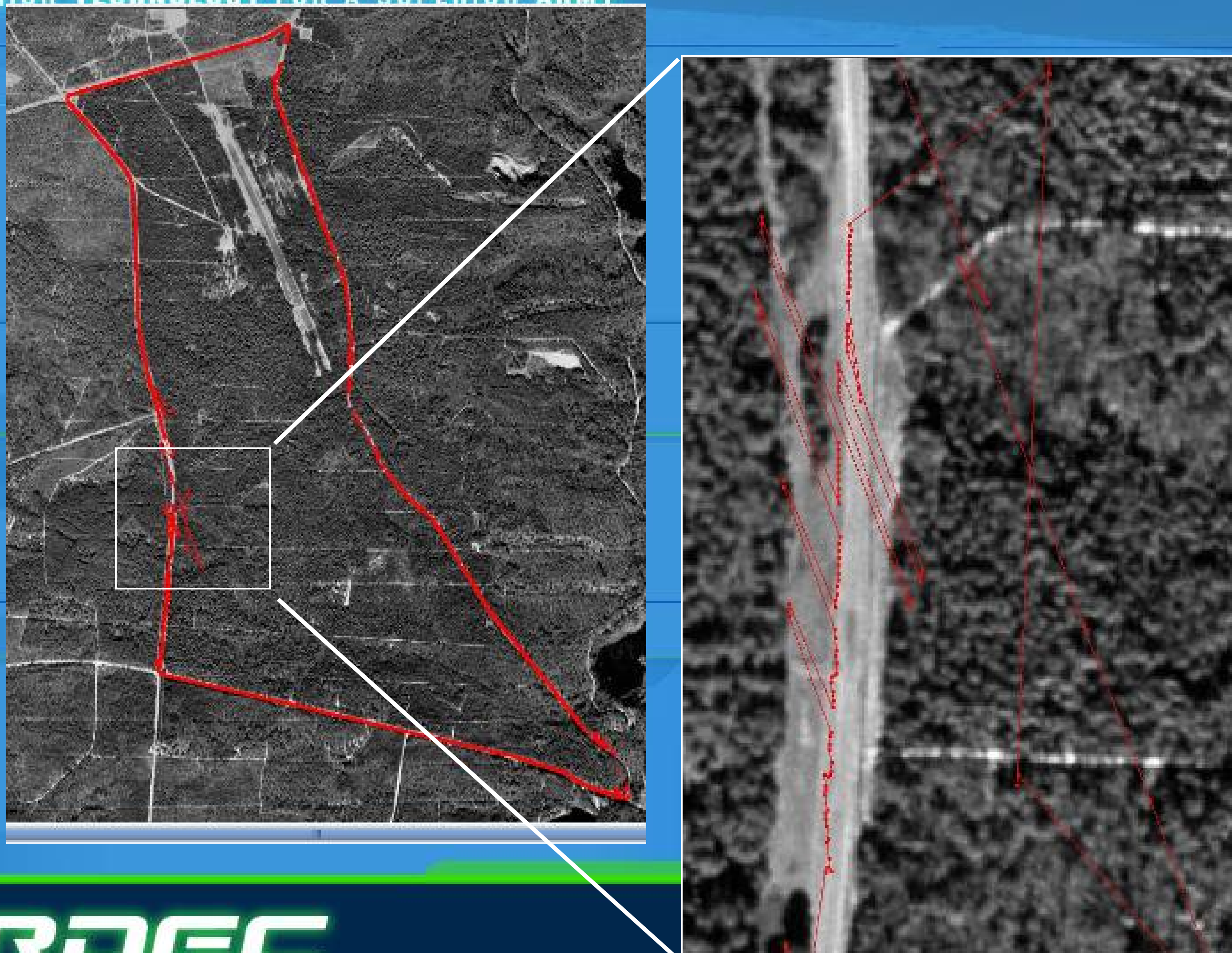
Navigation data is neither reliable nor available

- 300+ m jumps
- Up to 4 minute outages

Navigation limitations require additional perception for tight angle turns

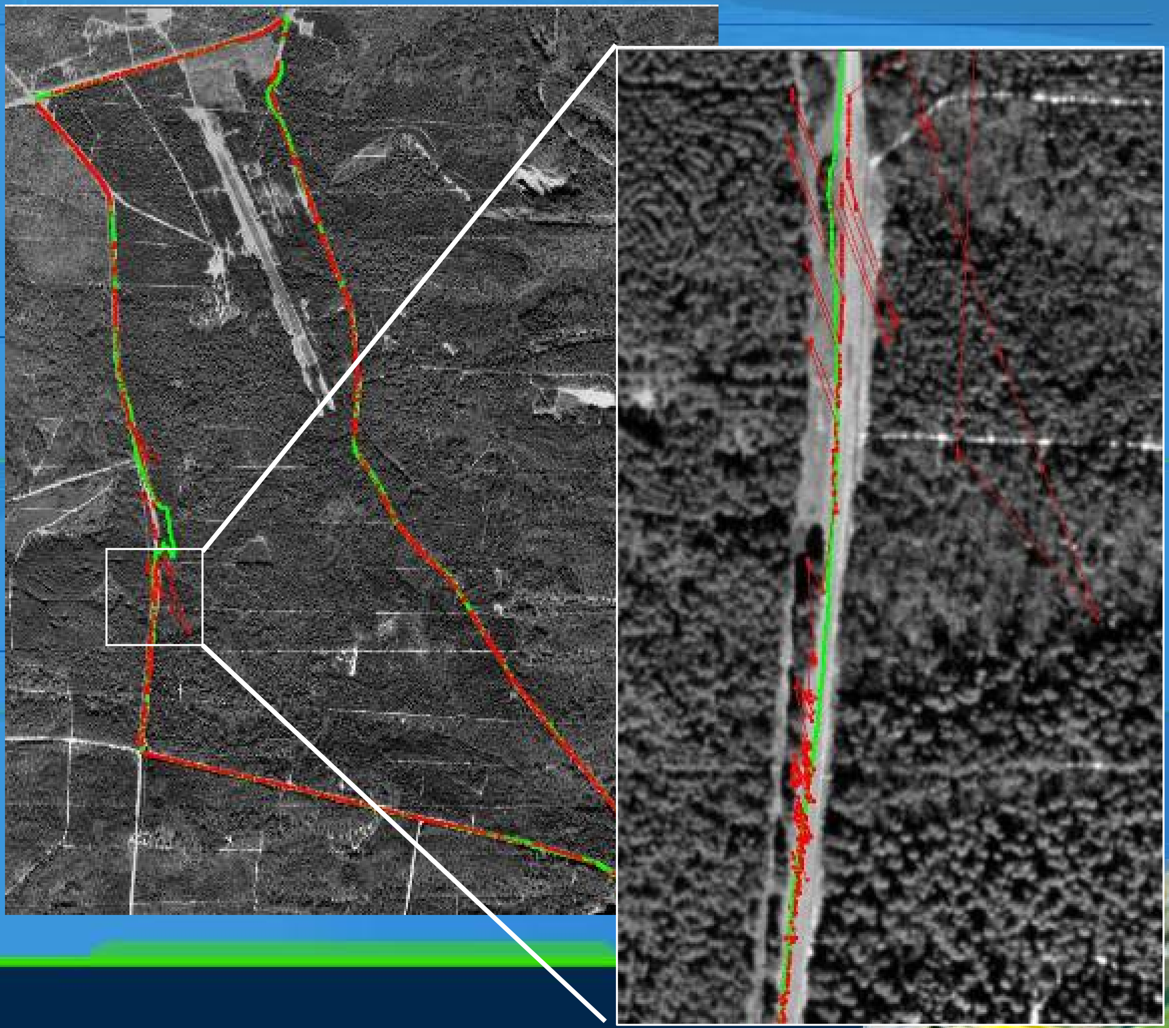
Conclusion: Requires additional investigation into GPS unit

Reliability and Availability of GPS



Improved Navigation

- Uses distributed sensors on the vehicle
- Loosely coupled Kalman Filter
- Works with SGPS, WAAS or Single GPS coverage
- Experienced outages of 4 minutes and pops of 300+ meters
- In these conditions, stand alone geo-based following is untenable



Perception-based Vehicle Following

Uses Radar to detect vehicle

Uses Vision to aide in tracking vehicle

The radar and the camera have matching FOV

Model based expectation and localization

Performance

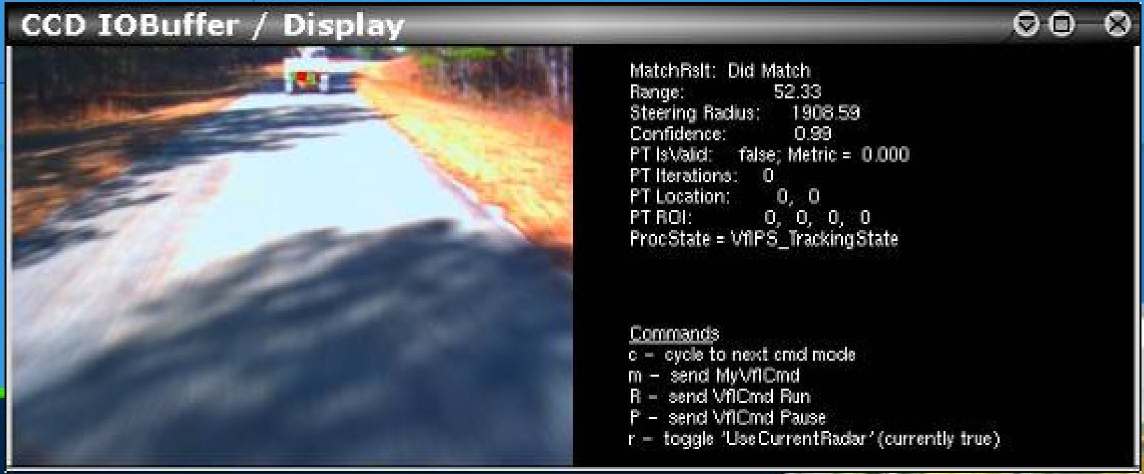
- Detections throughout the range of the radar
- Maintains a track throughout the FOV

Sends a steering vector to COMA for fusion with other behavioral inputs

Independent of Absolute Navigation Solution

Picture

- Follower distance of 50 meters
- Active Behaviors
  - PVF
  - Waypoint Following
  - Gap Maintenance
  - Radar Safe Distance



Obstacle Detection/ Avoidance

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- **Works with either Radar or Sick Ladar sensor**
- **Acts as a "Negative Behavior" blocking steering directions that collide with hazards**
- **Sends a steering and speed vector to COMA for fusion with other behavioral inputs**
- **Independent of Absolute Navigation Solution**
- **Test (video)**
  - Follower distance of 60 meters
  - Obstacle placed in follower path after lead passes
  - Active Behaviors
    - Obstacle Avoidance
    - Waypoint Following
    - Gap Maintenance
    - Radar Safe Distance
    - Perception-based Vehicle Following

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Planned Technology Development

- Turnkey Operation
- Low-Cost User Interface
- GPS Robustness Algorithms
- Improved Perception Based Vehicle Following
- Dynamic GPS States
- Tight-Geometry Turns
- Improved ODOA
- Expanded/Selectable Gap Distance
- Multi-follower Convoy Study

Planned Experiment

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- Driving towards requirements generation
- TARDEC partnered with Combined Arms Support Command (CASCOM)
- Two scenarios
    - Safety
    - Situational Awareness
- Use feedback for improved technology development as well as requirements generation

Questions?